BOOK OF THE SILK WORM

SUSAN MINNS

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Book of the Silkworm

A PLEA FOR THE CULTIVATION OF SILK AND THE SILKWORM IN THE UNITED STATES

BY

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To the Memory of

LOUIS PASTEUR

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Book of the Silkworm

INTRODUCTION.

MY plea for the cultivation of silk and the silkworm in the United States is founded on the researches of Louis Pasteur.

For some years previous to 1870 the silkworms of Southern France and adjacent Italy had suffered from an epidemic of disease which caused financial loss to the country and great privation and suffering to the peasantry. Finally the Emperor Napoleon III, called upon Louis Pasteur, at the head of the scientists of the day, to aid in restoring the industry.

His mastery of the situation, his studies of the two fatal diseases: *Pebrine (Black Death)*, and *Flacherie (Flat Death)*, and his

cure are given in his books, *Les Maladies des Vers à Soie,* published in Paris in 1870.

His cure, really prevention, was simple. The female moth lays her eggs on a small square of cloth, where she is placed after mating. She dies, and is then pinned in a corner of this cloth for examination.

A deep cut is made in her abdomen and some of the entrails drawn out with a glass pipette. Diluted with a few drops of pure water, some of it is mounted on a microscope slide with a cover glass and examined under a compound microscope at a power of fifty diameters.

If the black oval cells or chains and clusters of cells of *Pebrine* are present, the cloth, with moth and eggs, is burned at once; but if free from disease, the eggs are put aside for breeding with certainty of success.

This is the simple method, which, faithfully carried out, brought back a flourishing industry, and restored France to its former prestige.

Dr. Benjamin Franklin advocated in his

day the cultivation of silk. The only silkworm thought of then was the *Bombyx Mori,* or *Mulberry Moth.* The idea was to raise silk for *export,* as a raw product, for there were but few textile mills.

Mulberry trees were imported and planted and are now found from Maine to Alabama. It was not a success,—that is not remunerative. Men and boys could not be spared to pick the leaves, and reeling the silk from the cocoons took much time and care that was needed for other and more pressing duties. The verdict was that silk raising was not suited to the genius of the American people.

An old print of 1839 shows men and boys gathering *Mulberry* leaves from tall trees, using ladders and baskets swung from ropes. Still other attempts have been made from time to time, but without permanent results.

Now, however, there is a change and a very extraordinary one. The country has gone upon a silk basis. It *demands* silk for all purposes, useful as well as ornamental.

Our cotton textiles are no longer in favor. The ginghams and fine goods we plumed ourselves upon, are left on the shelves, and silk has come to stay.

Silk lends itself to the production of materials, both luxurious and magnificent, but it also lends itself to the simplest comfort. It is three times as strong as flax. It is almost waterproof. It is not easily soiled and it launders with the utmost ease. It does not burn readily, taking fire and blazing, but chars.

It is durable; for, in India, garments of native silk pass down as heirlooms from mother to daughter, and no Dame Fashion forbids it.

It is good political economy to produce what we consume. In this case how can it be done?

THE FOOD OF THE SILKWORM.

The Mulberry and Its Allies.

THE food of the silkworm is first to be considered. The *Mulberry* family and its *Allies:*

The White Mulberry (Morus alba).

The Black Mulberry (Morus nigra).

The Russian Mulberry (Morus rubra).

The Osage Orange (Maclura aurantiaca). This is known as *bowwood.*

The Fig Family (Ficus).

The Bread Fruit Family (Artocarpae).

The Paper Mulberry (Brussonnetia).

The White Mulberry, long ago introduced, is found everywhere.

Morus alba is planted by seed from the white insipid fruit, by cuttings, and by layering.

A small tree, cut down, sends up shoots. These are bent over and fastened in the ground and send up shoots from every node. The *Mulberry* has this peculiarity. If a branch be twisted, it easily separates, and each strip planted in the ground sends up shoots. In Persia the *Black Mulberry* (Morus nigra), is perferred to the *White Mulberry*. But the Persian silks do not take rank with the Chinese silks as a rule. This *Black Mulberry* has the pleasant edible fruit.

The *Red Mulberry* (Morus rubra) is the *Russian Mulberry*. It is diaecious and the fertile tree has long strings of sweetish, insipid fruit.

All these trees have a milky juice, which contains mannite and succinic acid, which is slightly resinous.

There are many varieties and hybrids. Luther Burbank writes, as follows, of his developing a *Mulberry* tree, that under the same conditions, produced twice as much

The Mulberry Tree Developed by Mr. Burbank for a Japanese Customer. It Produces Almost Twice as Much Nourishment for Silkworms as Older Varieties

foliage. This was for a Japanese silk-grower, to whom the grafts were forwarded:

"Once a new variety is ready for distribution, I am confronted with the necessity of making all this work and planning, and this final achievement, of practical use to myself and the world, and there are three methods by which this is done. I have referred to the plan of filling an order, as in Japan. It was a Mulberry tree that, with about the same growing conditions and fertilization as the older varieties, would produce nearly twice as much foliage for the feeding of silkworms. When I had completed the long and complex experiments that ended in success, I forwarded the grafts to Japan, and thus the order was fulfilled."

The *Osage Orange* (Maclura aurantiaca) has long been successfully used for silkworms. It is an allied genus of the *Mulberry* and also has a milky juice or sap. Another name is *bowwood*. It is used for hedges all through the West. If it could be improved, as Burbank improved the *Mulberry*, its thorns

turned to foliage, it would surpass any plant for feeding silkworms.

The Fig Family are allied to the *Mulberry* and have even more of a milky juice than the others, as the *Ficus elastreus,* or rubber fig shows.

There is the Brussonnetia or *Paper Mulberry;* and the Artocarpae, or *Bread Fruit Family* is near of kin, and both of these have milky juice.

Whatever plant may be chosen, it should be grown, Chinese fashion, as a hedge or shrub, never as a tree. A branch of *Mulberry* may be twisted into strips by the hands and planted in the ground (layering), when it quickly sends up shoots.

To cultivate the silkworm, sound, healthy eggs of a good strain are obtained. At a temperature of 75 degrees *Fahrenheit* they hatch out and all at once. There are four moultings. Tended and fed faithfully and abundantly, the worm, at the end of sixty-

three days, spins its cocoon. Ten days is allowed for this spinning and the change of the worm into the pupa.

It is then most important to kill the cocoons, for if the moth is allowed to emerge, the hole it makes ruins the cocoon for spinning.

The killing is done by heat, by steam, and by boiling water; but the latest method is the use of chloropicrin, one of our war gases.

A war gas made by Prof. Gabriel Bertrand of the Pasteur Institute has found a peace time use in the silk industry. The silk cocoons are gassed by small quantities of chloropicrin, which was proved exceedingy practical and easy to handle. The gas has been tried in various silk-raising centers and has been found to possess marked advantage over killing the cocoons by baking or steaming. Under the prevalent methods of silk culture the cocoons have to be all sold within a period of two or three weeks, but the use of chloropicrin promises a practical way, it is said, for the growers to turn the cocoons into non-

perishable merchandise which can be sold when the market is best.

The cocoons then become a marketable commodity, and can be kept for sale at the best prices.

The first and most important thing is the food and the plant to be cultivated.

THE BOMBYX MORI OR SILKWORM.

THE silkworm of the *Bombyx Mori* is two inches long when full grown. Including the head and jaws it is made up of thirteen segments or rings. The second, third and fourth ring has each a pair of three-jointed, sharp-clawed feet, one on each side of its ring. These are the real feet and reappear on the moth after moulting.

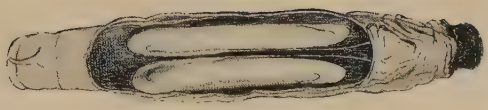
Rings six, seven and eight have each two claspers, one on each side, three-jointed and ending in rounded pads fringed with stiff black bristles, somewhat curved. The last ring has a pair of claspers, also fringed, and above a curved horn, as in the genus *Cecropia*. These claspers disappear in the pupa. The spiracles, or breathing holes, are on each side of each ring, as in all caterpillars.

THE SILKWORM—BOMBYX MORI—LIFE SIZE

The head is large with wrinkled folds, and there are eyes on its facial surface, though how much it sees is a problem. There are also bristles which are sensitive and may serve as guides. The two spinnerets bring the silk down to the mouth, each a thread from its respective silk gland and there these unite and form one thread.

The silk glands lie lengthwise in the body below the other organs, extending from the fourth to the tenth ring. If stretched full length they would be much longer than the caterpillar, but they are closely convoluted at each end. Their color is yellow, like ripe Indian corn, and they are pulpy to the touch. Hardened by acetic acid they are removed entire and become the "silk gut" so invaluable for fishing tackle, as nothing can take their place for strength and durability.

A thread from each gland passes out to its spinneret and this gives a double thread, one from each spinneret and united by some manipulation, it may be of the mouth parts. This



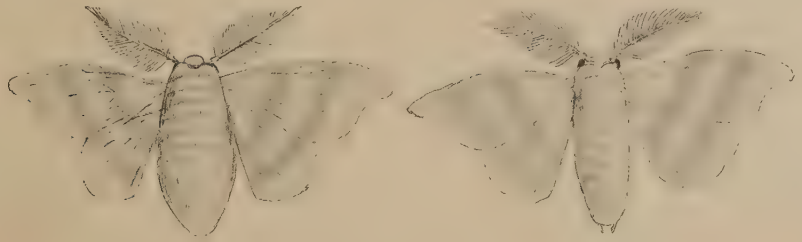
SILKWORM CUT OPEN TO SHOW THE SILK GLANDS

double thread is said to measure eighty-five yards in length, or two hundred and fifty-five feet.

Both the male and female moth spin cocoons. The male cocoons are slightly pointed.

This agrees with the traditions of the *Basse-Cour,* or French Poultry Yard, where the oval eggs are said to produce pullets; and the pointed ones to hatch out cockerels. This fact enables the cultivator to select equal numbers of male and female cocoons for raising eggs, according to the advice of the best authorities.

Five days are required to spin the cocoon, five more for the change into the pupa, and in twenty to twenty-four days, the moth comes out. It emits a liquid which dissolves the silk of the cocoon, enabling it to creep out, leaving a large hole in the end of the cocoon. This ruins the cocoon as far as spinning off the thread is concerned, and explains why the



FEMALE MOTH MALE MOTH

BOMBYX MORI

cocoons must be "killed" within twenty days after spinning.

The moth now is hardly more than an inch in breadth across the wings, a small moth from a two-inch caterpillar. It has lost all its appendages, retaining only the three pair of forelegs. It has no jaws, nor any mouth parts. Only a hole, like a pin hole in front, through which came the liquid solvent. Its eyes are large and prominent, and both the male and female have large and beautifully feathered antennae.

It flutters and runs about, but cannot fly. In a sunny enclosure the moths are left to mate, for twelve hours. The males die and are removed. The female hardly moves after mating. She is placed on a cloth, five or six inches square, and there lays her eggs. These are dripped or sprayed onto the cloth where they adhere by their own moisture. The estimate is three hundred eggs to a moth, the weight two grains. The moth dies then and is at once pinned in a corner of the cloth for

examination under the compound microscope as described on page 14.

This examination is simple and easily taught, but it is vital to the industry. It must be done by loyal and faithful hands, as well as by skillful ones.

The results of any carelessness or treachery are appalling.

The raising of eggs will become no doubt an industry by itself. The trade mark is easily stamped on the squares of cloth on which the eggs are laid, so that each breeder builds his own reputation.

Fine wire gauze cases are thought the best guard for the tested eggs. They should be hung up where they will have pure fresh air at a temperature of 55 degrees *Fahrenheit.* The eggs absorb much oxygen from the air and grow dark and much heavier. They are to be guarded from mice, ants, ichneumon flies, and from all odors, such as drains, gas, smoke, and tobacco.

YO-SAN-FI-ROK.

[*Translated into Dutch*].

"The Art of Raising Silkworms in Japan," by Dr. J. Hoffman of Leyden, Interpreter to the King of the Netherlands. Published in French in Paris and Turin, 1848, with Fifty Illustrations from the Original Designs.

THIS curious work was brought from Japan and added to the rare Indo-Japanese Library of the King of the Netherlands by M. Siebold after his scientific mission to Japan.

It gives the very earliest account of silk and its cultivation in China, with many traditions and legends, unlike our encyclopedias and far more entertaining.

The princess and the cruel queen stepmother is one tradition, the four moults representing the death of the princess at the

command of the step-mother, and her return to life, and her final triumph.

The imperial mandates appointed the day for the work to begin, and directed the empress and her court ladies to forego all pleasure and amusement, and to occupy themselves with the care of the silkworms for the necessary period.

As soon as the foliage of the *Mulberry* was sufficiently developed, the ceremony began. The empress herself picked the first leaves, and then the active hatching and feeding began. When the cocoons were duly spun there was a grand celebration. This time of feasting and rejoicing is very quaintly illustrated in the pictures.

Eight species of silkworms were described in old China, varying in size and color of the cocoons. Two are especially remarkable: the first for having three broods a year, the second for having only two moultings.

Yo-San-Fi-Rok points out that every "educator" of silkworms should be keenly alert to

note and care for such silkworms as are more robust and forward, and by giving them attention, obtain better eggs for broods, and so secure constant improvement in the industry.

Certain provinces in both China and Japan were set apart for egg-raising. The squares of paper or cloth on which the eggs were laid, and to which they adhered, were stamped with the special name of the province.

As soon as the leaf-buds of the *Mulberry* begin to unfurl, the eggs must be hatched. Even the young leaves are torn in strips and laid on a tray. As the worms hatch they are dropped from the cloth by a slight tap into the centre of the tray of leaves, until the very last worm is hatched out.

Even temperature, fresh warm air, abundant food and space, and constant vigilance are dwelt upon with ardor.

"Devoted care," says the *Yo-San-Fi-Rok*, "for thirty-six days, or, at the most for forty days, and your task is over and an abundant harvest rewards you!"

The results of the folly and carelessness of the ignorant and negligent is told in the story of the people of a certain village. After a long journey for the eggs, they placed them safely near the ceiling. Then, without thought, lighted a fire on the hearth below. Of course in an hour's time all vitality in the eggs was destroyed by such stupidity. The cocoons were killed by boiling water, according to the pictures, and many cocoons, floating in hot water, were required to make up a thread to be reeled off for use.

The cocoons are kept in hot water while spinning off the thread, eight to twelve cocoons being spun off together, to make a sizable thread.

Each province had its own method, but the rule in all was to begin spinning within five days after the cocoon was finished. So there should be no loss from the moth's spoiling the cocoon by coming out.

The picture represents the reeling off of the silk on a very primitive winder. The

REELING THE SILK FROM THE COCOONS

cocoons are softened in boiling water. It must not be too hot, and a jar of cold water is at hand to temper the heat. The threads from the cocoons pass out through a loop of finely plaited human hair and form one thread. As one cocoon is reeled off, a new one is neatly joined on, until the skein or ball is completed to the desired amount.

The tutelary divinities of the silk industry are many and powerful. In China the wife of the Emperor Hoang-ti comes first. She is represented by the constellation of the four stars, *Scorpio*. There is a long list of other divinities, descendants of earth or fire. Love of gain is punished. The man who acts from duty and patrotism is rewarded.

Women and young girls make offerings to the divinities and pray to them for success, for skill in weaving and design. If a spider drops down upon their offerings they consider it a favorable augury.

Four illustrations are given from the book *Yo-San-Fi-Rok*:

OFFERING PRAYERS TO THE DIVINITIES AND TUTELARY DEITIES

Grafting or budding the *Mulberry* trees.

Layering from the trees.

Offering prayers to the divinities and tutelary deities.

Reeling the silk from the cocoons.

The silkworm industry and those who understood it, seem to have come to Japan by way of Corea. Possibly the trees came the same way. There are some illustrations about the *Mulberry* plantations. They are not to be allowed to grow into tall trees, but kept low as shrubs or hedges. Shoots from trunks of trees are bent over and planted firmly (layered) in the ground, cutting them a little to make them take root. In time quite a grove rises around a stump. Larger growths are cut off and budded. As in China and in Japan, the care of silkworms is mostly in the hands of the women and young girls; gathering the leaves from low shrubs and hedges is easy for them.

The leaves must be free from dust. Dew or rain is shaken off and the leaves dried and

LAYERING FROM THE TREES

kept in the house until the right temperature to feed; never cold or wet, but dry and warm.

All odors are forbidden. The book specifies tobacco as deadly, but it also bans fennel, ivy *(Rhus),* walnut trees and even pine trees. No one who uses tobacco much touch the *Mulberry* leaves, and tobacco smoke is poisonous to the eggs.

The insipid white fruit of the *Mulberry* is not to be left on the twigs, for though the silkworms eat it greedily it is injurious.

Mice are a great danger, ants and crawling insects can be kept away by immersing the feet of the stands in water, birds, bats and ichneumon flies are to be guarded against.

Practice vigilance for forty days and then comes a rich harvest!

In regard to tobacco, it is singular that this old work *Yo-San-Fi-Rok,* translated from Chinese into Japanese, from Japanese into Dutch and from Dutch into French, should lay such stress on the fatal effects of tobacco:

"Tobacco smoke is fatal to the eggs."

GRAFTING OR BUDDING THE MULBERRY TREES

"No one, who uses tobacco in any form, must pick or handle the leaves."

"No one who uses tobacco must be suffered around where the silkworms are feeding."

Luther Burbank never employed any one who used tobacco. He said that the use of tobacco blunted the finer perceptions. The eyes of tobacco users could not be relied on. Neither their vision nor their sense of smell were normal. The qualities of color and fragrance, so important in his work, they could not differentiate. Their judgment, that nice balance of observation and comparison, was not to be trusted.

This is the most remarkable condemnation of tobacco possible!

If it is true that tobacco is so injurious to silkworms, it may explain some of the ill success of attempts at silk culture in the United States, as wherever it could be obtained the use of tobacco was universal.

REARING THE SILKWORM THROUGH ITS FOUR MOULTINGS.

THE quarters for rearing silkworms may be in a small building, in a sunny room, or even on a sun porch. But everywhere the same conditions should be observed and the same simple precautions taken.

The quarters must be sunny and well-aired. Yet the worms must never be exposed to direct sunlight, rather kept in the darkness. They must be guarded from drafts or currents of air. The air must be pure, and no smells or odors of any kind. No odor of manure from barns or stables, as that would mean ammonia and be most injurious. No smoke or gas from railroads or factories and no tobacco in any form.

The stands should be open shelves for trays of a convenient size, some two feet wide and rather longer. If they are latticed with

twine at the bottom instead of being solid, they allow the silkworm to crawl up and through to the fresh leaves, when placed over the tray in use.

The used tray is then removed, and carefully scanned to see that all the silkworms have climbed up to the fresh leaves. If a silkworm remains, it will clasp the edge of a leaf and can be so removed with care and not touched by the hand.

Blunt wooden forceps, or a feather and a wooden spoon, are good to use, rolling the worm into the spoon.

Any worm that seems "out of sorts" should be isolated and fed by itself under observation, and with care may yield a good cocoon.

All refuse leaves with the excrement or "frass" from the worms should be burned.

In the *Yo-San-Fi-Rok* every precaution is taken to destroy all refuse. It even says that the ashes may be put on gardens or ploughed land, but must never be used around the *Mulberry* plantations.

The unit of cultivation taken here is one ounce of eggs. That is between twenty-three hundred and sixty-five and twenty-three hundred and seventy eggs to the ounce, to become the same number of silkworms. These eggs must be from moths proved free of disease.

The chief expense is for leaves, and, as the object is silk, the leaves must be abundantly and generously supplied. The eggs hatch in from thirteen to twenty days after the temperature is raised to 70 degrees *Fahrenheit*. It may be raised to 84 degrees *Fahrenheit*, but never higher. They hatch all at once. The caterpillars are 1/12 of an inch long, dark and very hairy. They are dropped from the cloth into a tray of finely shredded leaves, by a tap of the finger on the cloth, and begin to eat very eagerly. They are kept in a twilight darkness by screens, no matter how sunny the room may be.

To the first moulting which is five days, they are fed twenty-three pounds of leaves at regular intervals and require nine square feet of space.

At the end of five days, the worms cease to eat and remain quiet.

They must not be touched or moved, but kept warm and in the dark.

They moult at early dawn. The skin splits down the back and the head comes out first. The worm frees itself from the skin, which it often eats. The head is much larger now, and begins to assume the wrinkled folds. This is called the lion moult on this account; as soon as the moult is over, the worm begins to eat greedily, readily climbing up into the trays of fresh leaves.

To the second moult, is twelve days. There is the same routine: sleep and quiet undisturbed for twenty-four hours. The dead skin gives them a gray color, but with every moult they become lighter and brighter in color.

They must be fed forty-two to fifty pounds of leaves daily, at regular intervals, day and night, and require one hundred feet of space.

The sound of the jaws in eating is audible.

The third and most important moult comes in eighteen days after the second. The

worms are now voracious, and eat whole leaves and small twigs.

They require two hundred and twenty-six pounds of leaves, whole and in twigs, fed daily. This must be divided into six feedings of every four hours, day and night.

The worms now require nearly two hundred and fifty square feet of space. One reason for so much space is that the silkworms must not crawl over each other.

If the silkworm is neglected or not sufficiently fed, it does not seek food nor wander away. It remains passive and dies.

It must be fed regularly and abundantly; and the harvest of silk is the reward for faithful care.

In eighteen days comes the fourth and last moulting. This is the last chance to feed and increase the silk. The worms slacken their feeding and lift their heads and seem to look about. As soon as they have eaten their last mouthful and passed away the last "frass" they emit a drop of liquid and are "ripe"!

In the latter feedings the sound of the jaws in eating is often as loud as the rain on a roof!

The trays must be looked over with the utmost care, lest a worm be lost. It even pays to count them.

Any discoloration or blackness demands the removal of such a worm.

Sometimes a worm turns pink. This is called muscadine, and any such worm must be taken out and burned.

A worm may become very stout. This is *grossièreté* or grossness, and such a worm may not spin. If it exudes any liquid and smells unpleasantly, it must be taken away and burned, and doubtful cases should be isolated and still fed as they may after all spin a cocoon, which is what is desired.

After the fourth and last moult the silkworms are to feed, as long and as much as possible, six times in the twenty-four hours, night and day.

They cease at last and with raised head seek for a place to spin.

The custom has been to use branched twigs, bundles of straw or broom corn, but there are many harmless weeds that dried and trimmed are now preferred. Plants of *Colza, Brassica* and *Sinapis:* the mustard and charlock found everywhere; *Baptisia Tinctoria,* the wild indigo, is very widely found, and one of our tumble-weeds, *Amarantus Alba* is common. All these are smooth and innocuous, without thorns or prickles, and are just about the right size and spread.

Being herbacious and not woody, they break and release the cocoons easily.

SUMMARY.

Thirteen to twenty days for the eggs to hatch.
Caterpillars one-twelfth of an inch.
Dark and woolly.
Twenty-three pounds of leaves daily.

To first moulting five days.
Forty-two to fifty pounds of leaves daily.
One hundred square feet of space.

To second moulting twelve days.
Fifty pounds of leaves.
One hundred square feet of space.

To third moulting eighteen days.
Two hundred and twenty pounds of leaves.
Two hundred and fifty square feet of space.

To fourth moulting eighteen days.
Two hundred and twenty-six pounds of leaves.
Five hundred square feet of space.

95 moths—1 ounce eggs—88 pounds of silk.

1520 moths—16 ounces of eggs—1408 pounds of silk.

From the hatching of the egg to spinning the cocoon is sixty-three days, or nine weeks.

From the egg to the egg again is two months.

From the hatching to the first moulting is five days.

To the second moulting,
Twelve days.

To the third moulting,
Eighteen days.

To the fourth moulting,
Eighteen days.

This is the last chance to feed the caterpillar and increase the silk. They soon begin to lift their heads and look about them for a place to spin.

THE DISEASES OF THE SILKWORMS AND THEIR PREVENTION.

THE great epidemic that so nearly destroyed the silk industries of France and Italy is called *Pebrine* or *Black Death.* It is a germ disease and highly infectious. It is always fatal and spreads with a rapidity that wipes out whole communities.

Pasteur found the cause at once, and almost as soon the cure. The silkworm turns black and dies. In its body the miscroscope shows dark cells, single and in groups, and chains of cells.

Prevention is the cure.

Flacherie, or *Flat Death,* is caused by cold, chill rain, wet food leaves, and exposure to draft, or to change of temperature. It is not thought infectious, and occurs among all caterpillars. Cold hail storms in the summer

often leave scattered on the ground dead caterpillars, flat, elongated, stringy. *Tripe* is another word for this disease.

Muscadine is the name of a disease in which the silkworm becomes pink and even red. The cause is a fungus *(Botryotis)* and is highly infectious in its last stages. The worm emits drops of liquid and smells unpleasantly. Careful observation of the worms on the trays quickly discovers so marked a change in color. The worm is picked out and burned.

This disease might easily become an epidemic!

Grossièreté or grossness is not a common disease. In the later moultings a worm may become abnormally large and swollen. It should be isolated and fed, for it may still spin a cocoon.

One source of infection is often unsuspected. The claspers or grasping feet of the caterpillar are fringed with sharp curved bristles on the lower edge. These may cut or

wound other caterpillars. After moulting, the skin is very tender, and crawling over each other on a crowded tray may cause wounds that give rise to infection. Plenty of space is important for this reason.

PREVENTION.

After the female moth has emerged from the cocoon and has mated, she crawls about very little. She is placed on a small square of cloth and remains almost motionless until she has laid her eggs. These are sprayed out, fanwise, onto the cloth and adhere by their own moisture. The moth then dies. At once she is pinned into a corner of the cloth with her eggs and is ready for miscrospic examination.

In the accompanying illustration the female *Bombyx moth* is shown with the back cut away so the egg duct can be seen in its convolutions around the viscera. Any disease that affected the moth must affect the egg duct and eggs, so close is the connection between

MOTH OF THE BOMBYX MORI
SHOWING THE EGG DUCT

them. So Pasteur's miscroscopic test decides. If the moth is free from disease, so are the eggs. If disease is present, the duct and its eggs cannot escape.

This scientific work of Pasteur with its success is fully told in *Les Maladies des Vers a Soie*. In France this work was intrusted to competent and loyal hands. It is simple but efficient when faithfully done.

At that time the epidemic wiped out some rare strains of silk. It was hoped by Pasteur that in some quiet village or mountain town some of these choice kinds might have survived. But he was most unsuccessful, and these strains will have to be recreated by patient selection and care.

THE FAMILY BOMBYCIDAE.

THE family *Bombycidae* are known as the silk spinners because the caterpillar spins a continuous thread.

The two silk glands folded back within the caterpillar send out each a thread to the mouth. By manipulation of the mouth parts it issues as *one* thread.

In spinning off the cocoons a number of these threads are united to form a thread large enough for weaving.

The *Mulberry* moth, or *Bombyx mori,* from its centuries of cultivation, takes the lead in value and importance.

Yet China and India, and I may add Japan, have still another silk on the market. This is the *Tussah silk* of a tan shade. It is spun by the *Antheraea Mylitta,* or *Tussah* moth.

This name is given as *Tussah, Tussar, Tussore,* and is also called *Shantung,* from that province in China.

These caterpillars feed on oak leaves and live in a wild state, the natives collecting the cocoons as a regular harvest. It is a tradition that the oak leaves give the tan color. That this genus is hardy and active is vouched for. But little information is given out. The silk is very strong and used in its natural color. When dyed or printed it is called China silk.

In this method of raising the *Tussah silk* may lie the solution of our problems for utilizing the wild species of silk spinners that are native to this country.

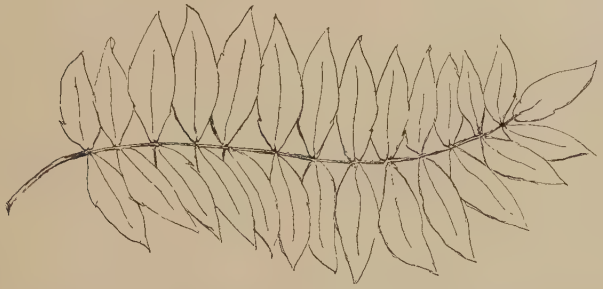
Even the *Ailanthus* moth, *Attacus cynthia,* from whose introduction so much was hoped, might prosper this way.

It spins a cocoon of white silk, not quite so lustrous as that of the *Bombyx mori,* but somewhat larger. It is very hardy as far North as Pennsylvania, and fends for itself. After it was turned down as a failure, it was so plenty that its cocoons could be gathered up *by the bushel* beneath the trees along the streets in Philadelphia!

The *Telea Polyphemus,* hardy even in New England, spins a *nearly* white cocoon, larger than that of the *Bombyx mori.* The caterpillar feeds on maple, linden, cherry (wild cherry) and elm trees. It is so hardy and finds food so readily, it seems as if it might be colonized, rather than educated and made valuable.

The *Attacus Ceropia* (*Samia Ceropia*) is our large hardy New England moth. It feeds especially on the scrub oak and it fastens its large, three-inch, brown cocoons on a twig lengthwise. So these cocoons are not found on the ground, but must be picked off; and collection on this account would present difficulties.

It is singular how the interposition of an insect, its added action, brings about a value in some of Nature's products. We see this occur in some of the resins, shellac, gum arabic, cochineal, and in some perfumes, and in this wonderful silk, most of all, a magic touch, changing handfuls of green leaves to potential silver and gold.



DECOMPOUND LEAF OF AILANTHUS GLANDULOSUS
MUCH REDUCED

THE SILKWORM OF THE AILANTHUS TREE.

THE *Ailanthus* silkmoth, *Attacus Cynthia (Philosamia Cynthia Drury)* was introduced into New York and Pennsylvania in 1861 on account of its large white cocoons and its reputation for being very hardy and easily raised. It did not bring any permanent success, but the moth is still found and has spread to some extent through the country.

The *Ailanthus* tree was first introduced from China in 1820 as a shade tree. It has spread all through the East and Middle West, is easily grown and has a striking tropical air. In cities it is a very desirable tree, with its tufts of long decompound leaves at the ends of its branches, like a tree fern. It is diaecious and the odor it sends out from its staminate flowers is acrid and disagreeable. Its pistillate trees are free from odor and pro-

SAMARA OR WINGED SEEDS OF
AILANTHUS GLANDULOSUS
MUCH REDUCED

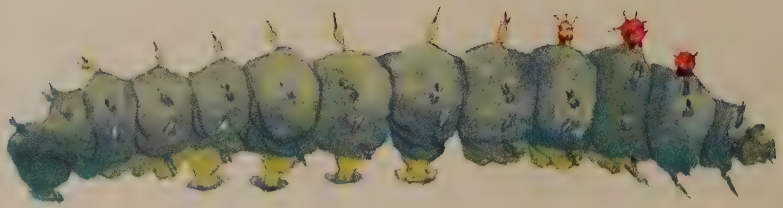
duce very handsome clusters of winged seeds of great vitality.

The *Ailanthus* silkmoth lays three hundred eggs and will produce two broods a year. It may lay eggs that lie dormant through the winter, to hatch out early in the spring, sometime in June. So another brood may be produced later, hatching in late mid-summer.

The *Ailanthus* tree produces its leaves in tufts centripetally. That is toward the centre. So there are young leaves in the middle of the tufts, giving tender and suitable foliage at all times.

Kept cut off at the height of three to four feet, it makes a shady, but not a compact, hedge, and its leaves, at this height, are gathered with ease.

Its winged samaras germinate in all sorts of nooks and corners, cracks in the pavements, in backyards and alleys, so great is the ease with which it grows, and it keeps fresh and green, in the dust and smoke of cities. In China its name is the *Tree of Heaven.*



ATTACUS CECROPIA

Life Size

OUR NATIVE SPECIES.
The Problems of Their Cultivation.

OUR native species of *Bombycidae* include two very remarkable ones: *Telea polyphemus* and *Attacus cecropia*. The favorite tree is oak, but maple, linden, elm, birch and cherry are eaten. The *Telea* moth lays nearly three hundred eggs, but fastened singly, or by twos and threes to the under side of oak leaves. It spins a large oval cocoon of strong, glossy and nearly white silk, which has been used for weaving.

In his exquisite book *Moths and Butterflies of the United States** Mr. Sherman F. Denton writes of this species:

"Many experiments have been tried from time to time with the view of making this insect of commercial value as a silk producer, but thus far,

*Mr. Denton's book was published in 1898.

I believe, without success. The greatest difficulty seems to be to unwind the silk from the cocoons rapidly enough and in a sufficiently large quantity to make the operation financially successful. It seems as if here was a fair field for the inventor. What clothing we might have if the silk from the cocoon of Telea polyphemus could be unwound, spun and woven into cloth inexpensively. Just think of the undergarments, socks, gloves, etc., we might wear, not to mention the curtains, portieres, rugs and carpets to our homes. I believe that this will be achieved at no distant day. As the food plants of this insect abound almost everywhere where there are forests, the food supply is unlimited. The caterpillars are hardy and could be reared out of doors in innumerable millions with the simplest contrivances; and with simple and efficient methods of manufacture, silk goods should be as cheap as cotton."

The *Attacus cecropia* or *Samia Cecropia,* is our largest silk spinner and both caterpillar and moth are very large and handsome. The moth lays its eggs singly or in two and threes

on the under side of leaves of scrub oak usually.

The caterpillar spins a long cocoon fastened lengthwise to a twig and not falling to the ground. It is an exquisite rich brown color. The moths fly by night and are widely distributed.

The caterpillar is one of our largest and a clear blue green when fully grown. On its back it has tubercles on the rings, pale yellow, orange and coral red, all studded with black hairs.

These species are finely figured in *The Moth* by Dr. J. G. Holland.

THE CULTIVATION OF OUR WILD SPECIES.

HE, who untrammeled by tradition undertakes the rearing and study of the *Bombyx Mori,* finds that he is dealing with a phenomenon: a highly specialized little creature, reduced by centuries of cultivation to two functions; the production of silk, and the continuing its own race.

It has no power to seek its own food. If unfed, if neglected, it dies helpless on the trays. The moths do not feed nor are they able to fly; and live only until they have mated and produced their eggs.

But with the wild species this is not the case.

They are, as caterpillars, active and alert, seeking their own food. As moths, they fly long and far. They have perfect mouth parts

and enjoy a rather "sporty" life before they die.

Many new problems must come up in trying to rear them. As they lay their eggs singly or by twos and threes on leaves of the oaks and scrub oaks and as the moth, like all the large moths, lays three hundred eggs, the question of what the moth will do in confinement arises. How to obtain the eggs for our starting point.

The way it prefers to fasten its cocoons is unlike the *Bombyx Mori.* If neglected, not fed, it starts out to forage for itself. It does the same if it does not like its food. It may prove an interesting study, but recalls the witty saying of the late President Eliot of Harvard: "One single-minded worm is more than a match for man."

THE IMPORTANCE OF CREMATION.

LL diseased moths or worms, all "frass" or excrement, with the remains of leafage on the trays should be burned.

Small terra-cotta crematories are recommended.

The *Yo-Sin-Fi-Rok* goes even farther. Ashes from the crematories may be used on ploughed land, but must never be used on the *Mulberry* plantations.

The trays in China and Japan are latticed with bamboo, but whether by bamboo or string, they are scalded frequently and dried in the sun and air.

Space for the worms is very necessary. The clasping feet of the silkworm are fringed with stiff, sharp bristles. Especially when freshly moulted, a worm, climbing over others on a crowded tray, will wound and prick other worms and infection may set in.

CONCLUSION.

UR hope of success in the raising of silk today is affected by several factors: we believe it sound political economy to raise what we consume, and we believe today in organized co-operation.

In the early attempts the eggs of the silkworm could not be guaranteed as free from disease. Now they might be furnished from authentic dealers and warranted.

The cocoons now can be sent to dealers to be wound. The pupae within the cocoons are killed by reliable and new methods and the cocoons are marketed at an auspicious time so as to command a good price.

Again dealers take the dead cocoons and spin off the silk from them at the mills. This delicate and tedious task is relegated to machinery.

The dyeing and weaving has long been

carried on well and successfully and will be increased.

We demand more silk every year. The consumption of silk rose from two pounds to six pounds per capita.

It should not be impossible to raise silkworms that should moult three times only in place of four. In some of our States two broods a year could be raised where the foliage can be furnished almost the whole year.

Three hundred eggs seems to be the largest number, as a rule, but there should be fully this number.

This constant study and selection will win results in this, as, in agriculture.

If a silkworm after the third moulting, seeks a place to spin, such a one should be at once held apart for breeding.

Large glossy cocoons, or any of a special tinge of color, as green or gold color, as sometimes occurs, should be at once reserved for culture.

This practical idealism, for which Americans are noted, gives this work of silk raising a higher interest. It becomes a study, almost of scientific value, and it is no longer tedious work.

Science comes to our aid today. The silkworm demands an even temperature; electricity will insure a temperature kept at a given degree. There must be fresh air; the electric fan gives air without cold draft.

The leaves must be dry and clean. Cold and wet leaves are most injurious. By electricity the leaves are dried, cooled and fed to the worms at a definite temperature. The electric torch enables one to examine the trays closely at any time.

Especially at the time of moulting, when they must be almost in total darkness. With the electric light the cultivator can study the trays and be sure of conditions. The worms spin in darkness and again the use of the electric torch is most valuable, showing whether the worms have found their covert

for spinning. There is certainty in place of doubt.

Such aids from science go far to insure success in this industry.

There seems no reason for tariff protection or subsidy.

If agricultural colleges interest themselves, if the Department of Agriculture advises and assists efforts for silk culture, as it so nobly assists in other directions, success would be certain.

Prizes and rewards would be a powerful aid, given for definite objects: such as increase of foilage, lessening the number of moultings, and especially for success in cultivating wild species.

When eggs can be obtained from absolutely reliable sources, and freedom from disease is assured, silk culture will become a profitable business and silk a home product that will enrich the American people.

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